LEVEL II

12

DDC
AUG 23 1979
C

AD A073100

DEPARTMENT OF THE NAVY
DTNSRDC

THE PERFORMANCE OF A CONCEPTUAL VERTICAL ATTITUDE TAKEOFF AND LANDING FIGHTER AIRCRAFT

by

Basil S. Papadales, Jr.

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

AVIATION AND SURFACE EFFECTS DEPARTMENT

DTNSRDC/ASED-79/06

January 1979

DAVID W. TAYLOR NAVAL SHIP RESEARCH AND DEVELOPMENT CENTER
BETHESDA
MARYLAND
20084

79 08 23 07

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: DTNSRDC/ASED-79/06 (14)
2. GOVT ACCESSION NO.:
3. RECIPIENT'S CATALOG NUMBER: (9)
4. TITLE (and Subtitle): THE PERFORMANCE OF A CONCEPTUAL VERTICAL ATTITUDE TAKEOFF AND LANDING FIGHTER AIRCRAFT (6)
5. TYPE OF REPORT & PERIOD COVERED: Final Report, Sep [redacted] — Dec [redacted]78
6. PERFORMING ORG. REPORT NUMBER:
7. AUTHOR(s): Basil S. Papadales, Jr (10)
8. CONTRACT OR GRANT NUMBER(s): (16) F61412
9. PERFORMING ORGANIZATION NAME AND ADDRESS: David W. Taylor Naval Ship R&D Center, Aviation & Surface Effects Department, Bethesda, MD 20084
10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: Project Element 62766N, Task Area ZF 61412001 (17), Work Unit 1612-500
11. CONTROLLING OFFICE NAME AND ADDRESS: David W. Taylor Naval Ship R&D Center, Aviation & Surface Effects Department, Bethesda, MD 20084
12. REPORT DATE: (11) Jan [redacted]79
13. NUMBER OF PAGES: 2 (12) 31p
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office):
15. SECURITY CLASS. (of this report): UNCLASSIFIED
15a. DECLASSIFICATION/DOWNGRADING SCHEDULE:
16. DISTRIBUTION STATEMENT (of this Report):

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report):
18. SUPPLEMENTARY NOTES:
19. KEY WORDS (Continue on reverse side if necessary and identify by block number):

Vertical Attitude Takeoff and Landing Aircraft
Aircraft Design
V/STOL Aircraft

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The performance of a conceptual 18,000-lb (8200-kg) vertical attitude takeoff and landing fighter aircraft is presented. The single-seat aircraft is designed around a single F100 turbofan. Contemporary avionics and materials technologies are assumed. The design payload includes an M61 cannon with ammunition and four Dogfight missiles. No compromises for mission capabilities, other than air combat, exist in the design. The fighter has a

(Continued on reverse side)

387 695

JOB

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(Block 20 continued)

combat radius of 308 nm (570 km) with a maximum level speed in excess of Mach 2 at altitude. Range, turning, and specific excess energy performance are presented. Weight and range performance penalties for the inclusion of conventional landing gear, a rotating cockpit, and a multi-engine design are summarized.

Accession For	
NTIS GRA&I	✓
DDC TAB	☐
Unannounced	☐
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or special
A	

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

The performance of a conceptual 18,000-lb (8200 kg) vertical attitude takeoff and landing fighter aircraft is presented. The single-seat aircraft is designed around a single F100 turbofan. Contemporary avionics and materials technologies are assumed. The design payload includes an M61 cannon with ammunition and four Dogfight missiles. No compromises for mission capabilities, other than air combat, exist in the design. The fighter has a combat radius of 308 nm (570 km) with a maximum level speed in excess of Mach 2 at altitude. Range, turning, and specific excess energy performance are presented. Weight and range performance penalties for the inclusion of conventional landing gear, a rotating cockpit, and a multi-engine design are summarized.

ADMINISTRATIVE INFORMATION

This report is the result of a study conducted by the author while assigned to the Office of the Director of Naval Warfare within the Office of the Deputy Under Secretary of Defense for Research and Engineering (Tactical Warfare Programs). Funding was provided by Independent Exploratory Development, Program Element 62766N, Task Area ZF 61412001, Work Unit 1-1612-500.

INTRODUCTION

The continuing need for air superiority fighter aircraft is demonstrated by the successive development of the F-15A and F-16 aircraft. In potential areas of conflict, such as the NATO Central Front, these aircraft would be used to gain and maintain control of the airspaces above the battlefield. Fighter aircraft will probably continue in this combat role well into the next century. The task of controlling the air will become more difficult because fighter airfields will be highly

susceptible to massive damage. Studies have shown that aircraft shelters and support facilities can be adequately hardened against reasonable enemy attacks. The runways and taxiways, however, are vulnerable to attack. Conventional munitions, including timed charges and mines, could be used to hamper timely repair operations. In the critical opening phases of a conventional NATO-Warsaw Pact conflict, delays in flight operations caused by such airfield attacks could prove critical to a NATO victory. One possible alternative to using conventional airfields is to use vertical takeoff and landing (VTOL) aircraft, which could operate directly from hardened shelters. An enemy would then be forced to attack with larger weapons delivered in greater numbers and with greater precision (compared to runway attacks). Dispersing the shelters would make this task more difficult.

A review of current fighter aircraft characteristics (Table 1) shows that modern aircraft have sufficient thrust to permit VTOL operations. These high thrust-to-weignt ratios result from the requirements for close-in air combat (dogfighting and high dash speed). One of the simplest and most promising VTOL propulsion concepts is to directly employ this high thrust to permit a vertical attitude takeoff and landing (VATOL) capability. Conventional landing gear may not be required, thus providing a potential weight savings.

A VATOL aircraft is not a new concept. The X-13 aircraft demonstrated the VATOL capability in the 1950's with turbojet propulsion. A propeller-driven aircraft, the YFY-1, also demonstrated a VATOL capability over 20 years ago. An unmanned turbojet-powered aircraft, the XBQM-108A, has recently demonstrated a VATOL capability.

Any VATOL aircraft requires a precision thrust vectoring system. Although costly, such systems have proven feasible. The X-13 used a

TABLE 1 - COMPARISON OF VARIOUS FIGHTER AIRCRAFT CHARACTERISTICS
(from Reference 4)

	F-5E	F-16A	F-18	F-15A	MiG-25	MiG-21BI	VATOL Fighter
Takeoff Gross Weight, lb	24,675	22,800	33,600	41,500	77,200	18,100	18,000
Empty Weight Fraction	--	0.64	--	0.63	0.57	--	0.61
Length, ft	48.2	47.6	56.0	63.8	73.2	51.8	58.0
Wing Span, ft	26.7	32.8	37.5	42.8	45.9	23.8	36.0
Wing Loading, lb/ft^2	83	76	84	68	128	73	50
Thrust/Weight[1]	0.65	1.10	0.95	1.20	0.63	0.62	1.20
Maximum Speed[2]	M=1.6	M=2.0+	M=1.8+	M=2.5+	M=2.1+	M=2.1+	M=2.1+
Service Ceiling, ft	53,500	50,000+	50,000+	66,900	72,200	59,000	55,000+

[1] Based on uninstalled thrust at sea level, standard day, static conditions
[2] At 36,089 ft, standard day

thrust vectoring nozzle (with 1950's technology); the XBQM-108A employs a system of control vanes to maintain the desired thrust vector (this system is not sophisticated by current U.S. aeronautical standards). For air combat aircraft, a thrust vectoring system adds more than a VATOL capability. Simulation studies have shown that the ability of a fighter to maneuver at extreme angles of attack can provide a substantial improvement in air engagement effectiveness. Exchange ratios as high as 4 to 1 have been calculated for comparable technology fighters where one aircraft had a substantial high angle of attack maneuver capability obtained with thrust vectoring.[1*]

A conceptual design study was undertaken to quantify the potential characteristics and performance of a VATOL fighter. To permit an accurate comparison with more conventional fighter aircraft, existing technologies were assumed. This report presents the results of this study.

DESIGN MISSION AND PAYLOAD

The VATOL fighter was designed for a short range air superiority mission, Table 2. A short period of combat was specified after a subsonic (M = 0.9) transit. The design study assumed existing engines and a specified payload; therefore, the radius of action was not specified. The mission combat included subsonic (M = 0.9) and supersonic (M = 1.2) flight at 20,000 ft (6100 m) altitude. The weapons payload called for 4 Dogfight missiles (250 lb (114 kg) each) and an M61A1 cannon with 400 rounds of ammunition. A single pilot was specified with 750 lb

---

*A complete listing of references is given on page 24.

TABLE 2 - DESIGN MISSION PROFILE AND REQUIREMENTS

1. Start engine, 1 min at GROUND IDLE rating
2. Takeoff, and transition 1 min at MAX T-O rating
3. Climb and accelerate to M = 0.9, 35,000 ft
4. Cruise out (cruise-climb)
5. Descend to 20,000 ft, no distance or fuel credit
6. Three 360-deg turns at M = 0.9, n = 7.3
7. Accelerate to M = 1.2
8. Three 360-deg turns at M = 1.2, n = 7.3
9. Drop ordnance
10. Climb to best cruise altitude
11. Cruise back (cruise-climb)
12. Descend to sea level
13. Loiter 20 min at best velocity
14. Approach to land, 1 min at 150 knots
15. Transition and land, 1 min at T=W rating
16. Shutdown, 1 min at GROUND IDLE rating
17. 5-percent fuel reserve

Notes:

- Standard day conditions
- Use installed engine performance data

Maximum level speed	M = 2.0+ at 36,089 ft
Design load factor	n = 9.0 at combat weight
Stall speed	120 knots
Payload	4 Dogfight missiles (at 250 lb) 1 M61A1 cannon with 400 rounds
Mission Avionics Weight	750 lb

(341 kg) of installed avionics (as capable as current lightweight fighter aircraft systems).

The VATOL aircraft was not required to have an engine-out capability; however, provisions for pilot ejection at all aircraft speeds and altitudes were required. A maximum level speed of M = 2.0 at 40,000 ft (12,200 m) was required; no stall speed was specified. A maximum sustained limit load factor of 9.0 in combat was required. The aircraft was designed solely for air-to-air combat; no requirements for other missions were set. No overload capability was required. An all-weather landing capability was required. The aircraft was designed assuming standard day conditions with military fuel flow conservatism (5-percent increase) and fuel reserves (20-min loiter at sea level and 5-percent fuel load reserve).

DESIGN PHILOSOPHY

There are several important issues concerning the design of a VATOL aircraft. First, there is the question of engine-out performance. For the VATOL fighter, it was decided not to require any engine-out performance, thus allowing the maximum potential VATOL fighter performance to be determined. Another design issue is the required pilot orientation during takeoff and landing while the aircraft is in a vertical attitude. For this study, it was assumed the pilot could adequately control the aircraft while on his back (and seated). This capability has not been demonstrated. An important issue in VATOL aircraft design is whether to provide a capability to operate from conventional runways in an overloaded condition; in this case, takeoffs and landings would occur with

the aircraft in a conventional (horizontal) attitude. Although, such a capability would add to aircraft usefulness, a penalty for conventional aircraft landing gear must be incurred. For this study, this penalty was considered too great, and no landing gear were assumed; a VATOL securing device, weighing far less, was assumed.

ENGINE SELECTION

Five existing, high performance, turbofan engines were considered for use in the VATOL fighter; see Table 3. All five engines had static thrusts of 16,000 to 30,000 lb (71.2 to 134 kN) at sea level; by-pass ratios ranged between 0.34 and 2.01. For the VATOL fighter, a moderate by-pass ratio was desired with a thrust of about 20,000 lb (89.0 kN). The VATOL aircraft was assumed to require a minimum thrust-to-weight ratio of 1.20 to account for thrust control and various losses.[2] Given these requirements, the F100-PW-100 turbofan engine was selected for use in the VATOL fighter. Performance for this engine was obtained from Reference 3. Assumptions concerning installed engine performance are listed in Table 4.

AIRCRAFT CHARACTERISTICS

The VATOL fighter design is presented in Figure 1, and aircraft characteristics are summarized in Table 5. The aircraft has a conventional fuselage and a high visibility cockpit with the engine mounted below the fuselage. The single fixed inlet is similar to the current F-16A fighter, which has the same engine. Venting panels are located around the inlet to provide additional inlet airflow during VATOL operations. The fuselage is 58.0 ft (17.7 m) long with a wing span of 36.0 ft (11.0 m), excluding

TABLE 3 - CANDIDATE ENGINE CHARACTERISTICS
(from Reference 3)

	Engines				
	F101-GE-100	F404-GE-400	TF30-PW-100	F100-PW-100	F401-PW-400A
Weight,[1] lb	4000	2000	3990	3000	3650
By-pass Ratio	2.01:1	0.34:1	--	0.63:1	0.65:1
Maximum Thrust,[2] lb	30,000	16,000	25,000	24,000	28,000
Length, in.	181	159	242	191	243
Diameter, in.	55	35	49	47	51

[1] Dry
[3] Sea level, standard day, and static conditions

TABLE 4 - F100-PW-100 TURBOFAN ENGINE CHARACTERISTICS

Uninstalled Static Sea Level Thrust	23,000 lb
Sea Level Static TSFC	2.48 lb/lb-h
Bare Engine Weight	2737 lb
Engine Nozzle Weight	213 lb
Engine Length	190 in.
Maximum Diameter	44 in.
Compressor Face Diameter	40 in.
By-pass Ratio	0.71
Installation Assumptions:*	
Power Extraction	70 hp
HP Bleed Airflow	0.4 lb/s
Engine Controls and Starting System Weight	51 lb

* Additional power extraction and bleed airflow may be required for short periods during takeoff and landing operations.

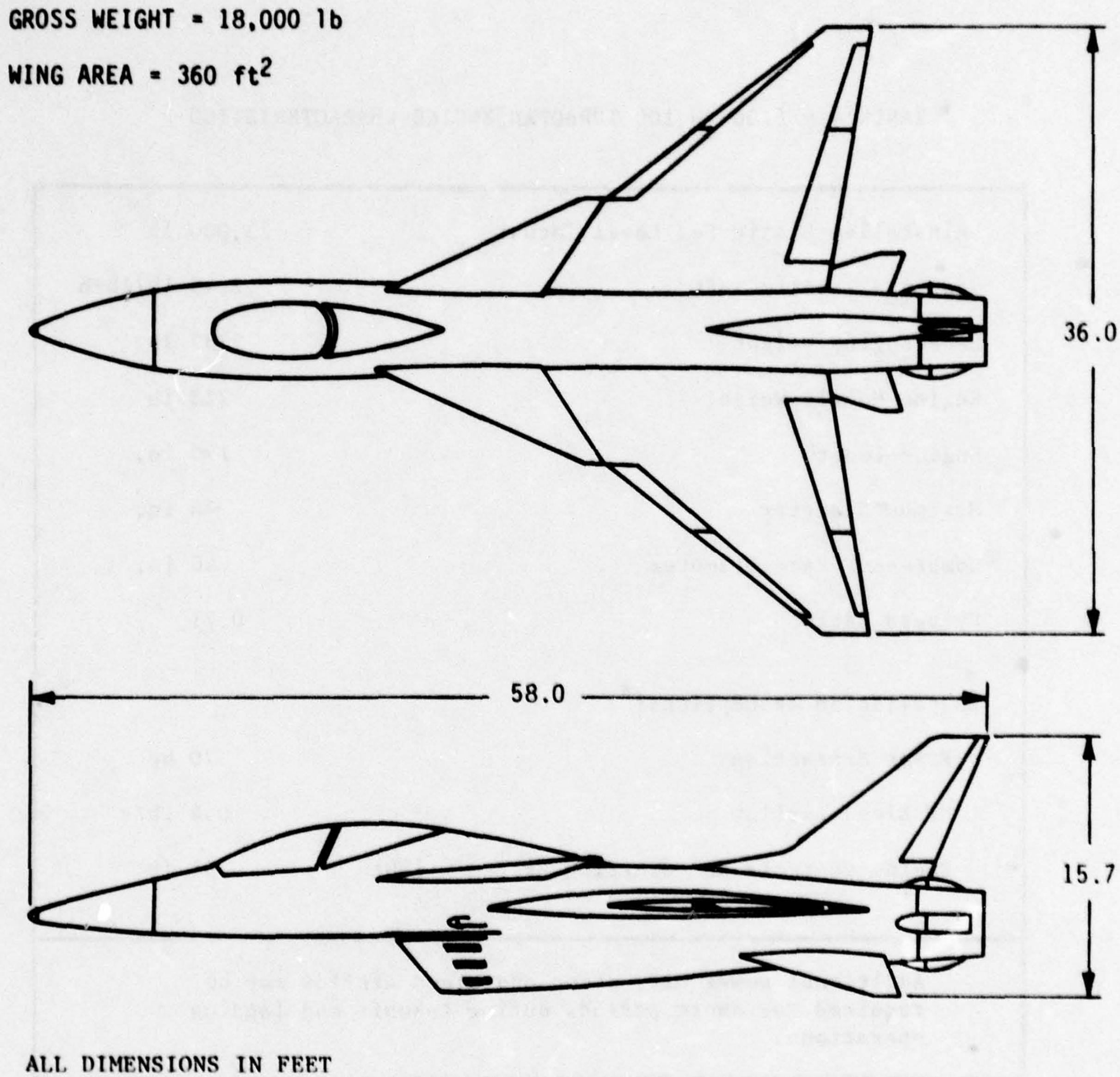

Figure 1 - Conceptual VATOL Fighter

TABLE 5 - VATOL FIGHTER CHARACTERISTICS PERFORMANCE

Takeoff Gross Weight	18,000 lb
Empty	10,960 lb
Wing Area	360 ft
Wing Loading (maximum)	50 lb/ft^2
Wing Aspect Ratio	3.6
Canard Area	72 ft^2
Canard Aspect Ratio	3.6
Installed Thrust (maximum sea level rating)	21,600 lb
Thrust/Weight (maximum)	1.20
Range/Endurance	
With combat ordnance, no combat	852 nm/2.4 h
With external fuel*, no ordnance, no combat	
Retain tanks	1336 nm/3.7 h
Drop tanks	1423 nm/3.9 h
Maximum Level Velocity (W = 14922 lb)	
Sea level	M = 1.45
40,000 ft	M = 2.10
Service Ceiling	55,000 ft+
Rate of Climb (maximum at sea level)	85,080 ft/min

* 1128 lb additional fuel in two 48 lb external tanks

tip-mounted stores. Two missiles can be located at the wing tips with two additional missiles at the inlet-wing junction. The M61A1 cannon is located in the forward lower fuselage. A small canard is located forward and above the wing leading edge. This close-coupled canard provides excellent aerodynamic control at high angles of attack; the Saab AJ-37 Viggen fighter employs such a control surface. A conventional vertical stabilizer is used for directional control; conventional ailerons are used for lateral maneuvering. Wing leading edge slats and flaps are employed to provide high lift in combat. The wing span is 36.0 ft (11.0 m); the maximum wing loading is 50 lb/ft^2 (2390 N/m^2), which provides considerable lift capability in combat.

The single F100-PW-100 turbofan is located to provide adequate inlet airflow and thrust control. Thrust vectoring is achieved with a swivelling nozzle (as on the X-13). Self-sealing fuel tanks are located in the fuselage above the engine. Provisions are included for airborne refueling.

The VATOL fighter has a takeoff gross weight of 18,000 lb (8200 kg), which was determined from the selected engine performance and the desired thrust-to-weight ratio. Component weights were calculated from equations developed from a regression analysis of fighter aircraft.[3] A conventional (aluminum, titanium, etc.) semimonocoque structure was assumed with advanced composite materials used only in the secondary structure. No modifications were made for advanced technology or VATOL-peculiar systems. The component weight breakdown is presented in Table 6. The empty weight fraction is 0.61; there is adequate internal volume for 5092 lb (2315 kg) of fuel. External tanks are required if the 1224 lb (556 kg) of ordnance is replaced

TABLE 6 - VATOL FIGHTER WEIGHT BREAKDOWN

Wing	1955 lb	
Canard	371	
Vertical Stabilizer	340	
Fuselage	2677	
Engine and Nozzle	2950	
Fuel System	316	
Engine Controls and Starting	51	
Surface Controls	569	
Air Conditioning/Deicing	212	
Flight Instruments	120	
Mission Avionics	750	
Electrical System	465	
Ejection Seat	145	
Miscellaneous Equipment	39	
Empty Weight		10,960 lb
M61A1 Cannon	524	
Operating Empty Weight		11,484 lb
Pilot	200	
400 Rounds of 20-mm Ammunition	224	
4 Dogfight Missiles	1000	
Zero Fuel Weight		12,908 lb
Design Mission Fuel	5092	
Takeoff Gross Weight		18,000 lb

with extra fuel. There is no overload capability. The characteristics of the VATOL fighter are compared to other air combat aircraft in Table 1. The VATOL fighter empty weight fraction is lower than comparable high performance conventional U.S. fighters. The VATOL fighter also has a lower wing loading which provides enhanced combat maneuverability.

AIRCRAFT PERFORMANCE

Aircraft performance was calculated using the contemporary methods described in Reference 3. The VATOL fighter drag was calculated in detail. Figure 2 presents the zero lift drag variation with speed. The drag coefficient (with no lift) is maximized at M = 1.20 with a value of 0.0390. The subsonic zero lift drag coefficient is 0.013. This relatively low value can be attributed to the low aircraft wing loading. Cruise efficiency is also shown in Figure 2, with a maximum L/D of 13.6 possible at subsonic speeds.

The VATOL fighter performance is summarized in Table 5 and compared to other fighter aircraft in Table 1. The VATOL capability results in an aircraft with exceptional climb and acceleration performance. The aircraft can achieve M = 1.45 at sea level and M = 2.10 at 40,000 ft (12200 m) altitude; the service ceiling is in excess of 55,000 ft (16800 m). An estimated flight envelope is shown in Figure 3.

With the design mission and payload specified in Table 2, the VATOL fighter has a radius of action of 308 nm (570 km). With no combat and all ordnance retained, the aircraft range is 852 nm (1580 km). Off-loading the ordnance and using drop tanks will increase the range to 1423 nm (1880 km). Figure 4 presents the loiter performance of the

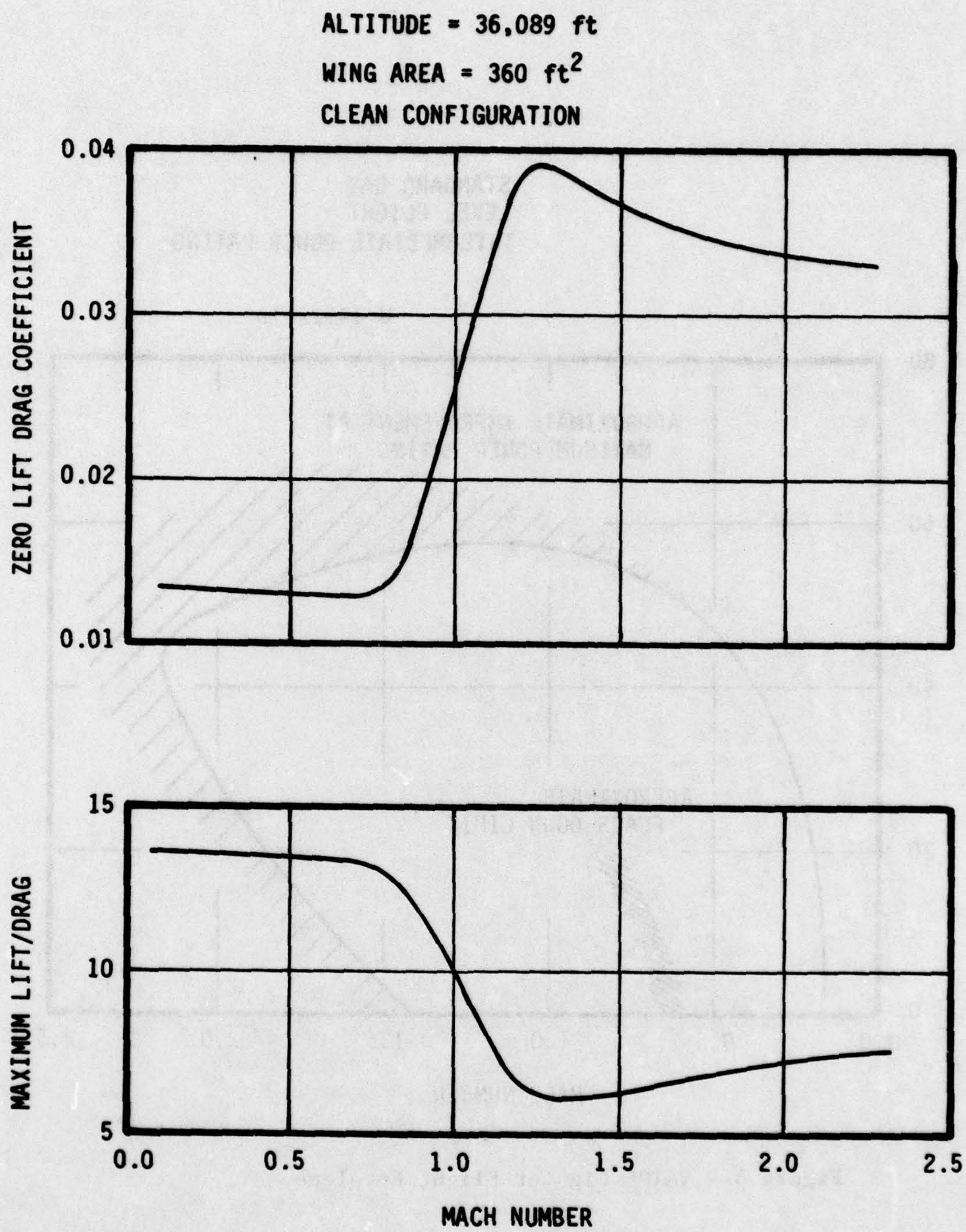

Figure 2 - VATOL Fighter Aerodynamics

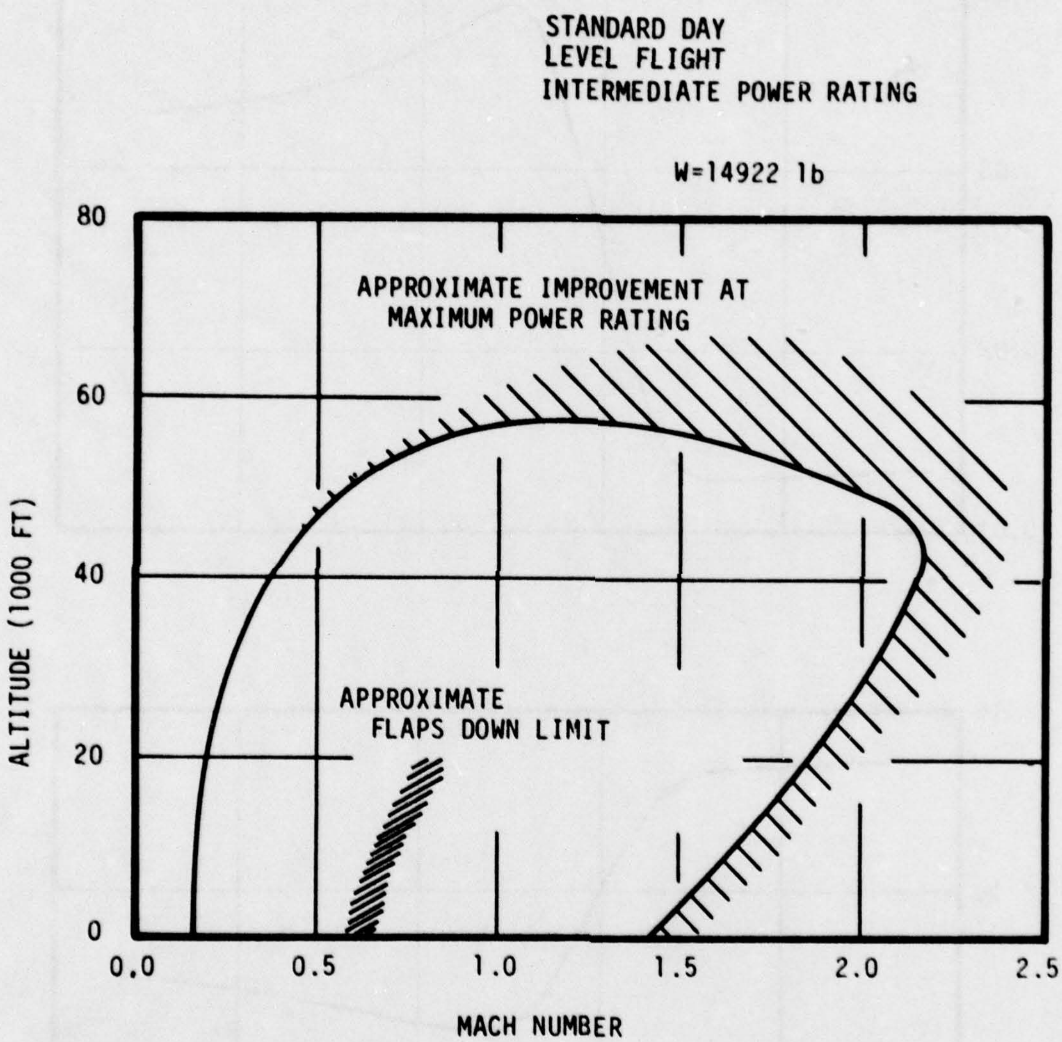

Figure 3 - VATOL Fighter Flight Envelope

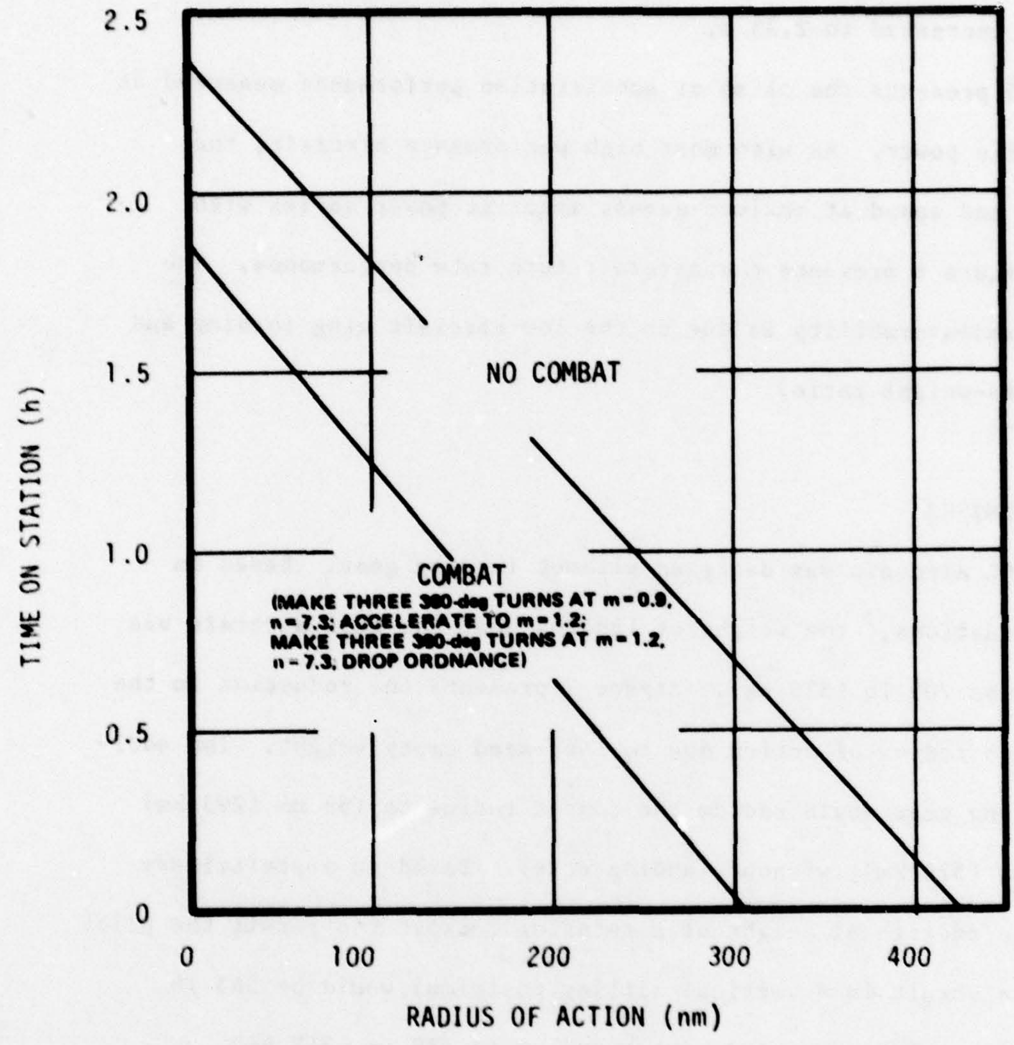

Figure 4 - VATOL Fighter Range-Endurance Performance

1013 n.mi. (1880 km). Figure 4 presents the loiter performance of the aircraft. With the specified combat (and dropping all ordnance), the overhead endurance is 1.85 h. With no combat and retained ordnance, the overhead endurance is increased to 2.35 h.

Figure 5 presents the climb or acceleration performance measured as excess specific power. As with most high performance aircraft, the magnitude of and speed at maximum excess specific power varies with altitude. Figure 6 presents the aircraft turn rate performance. The exceptional maneuverability is due to the low aircraft wing loading and high thrust-to-weight ratio.

DESIGN COMPROMISES

The VATOL aircraft was designed without landing gear. Based on regression equations,[3] the weight of landing gear for this aircraft was estimated to be 705 lb (320 kg). Figure 7 presents the reduction in the design mission radius of action due to increased empty weight. The addition of landing gear would reduce the combat radius to 158 nm (293 km) (from 308 nm, (570 km), without landing gear). Based on a preliminary analysis, the additional weight of a rotating cockpit (to permit the pilot to land the aircraft in a vertical sitting position) would be 545 lb (248 kg); this would reduce the combat radius to 188 nm (348 km).

Consideration was also given to employing two engines to provide an engine-out capability; however, no existing engines were available and a scaled F100-PW-100 turbofan was assumed. An engine-out capability was found to increase the aircraft gross weight to 24,500 lb (11,100 kg) and the empty weight fraction to 0.63. This larger aircraft would have

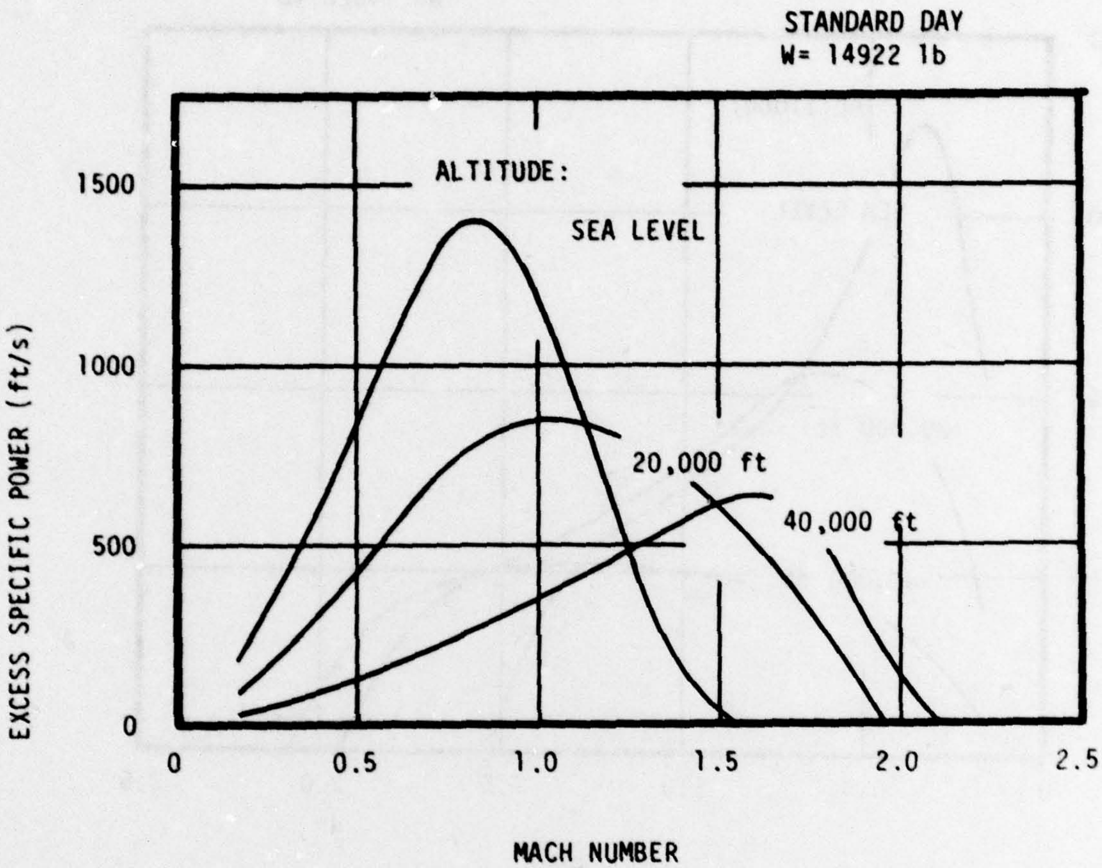

Figure 5 - Excess Specific Power Characteristics

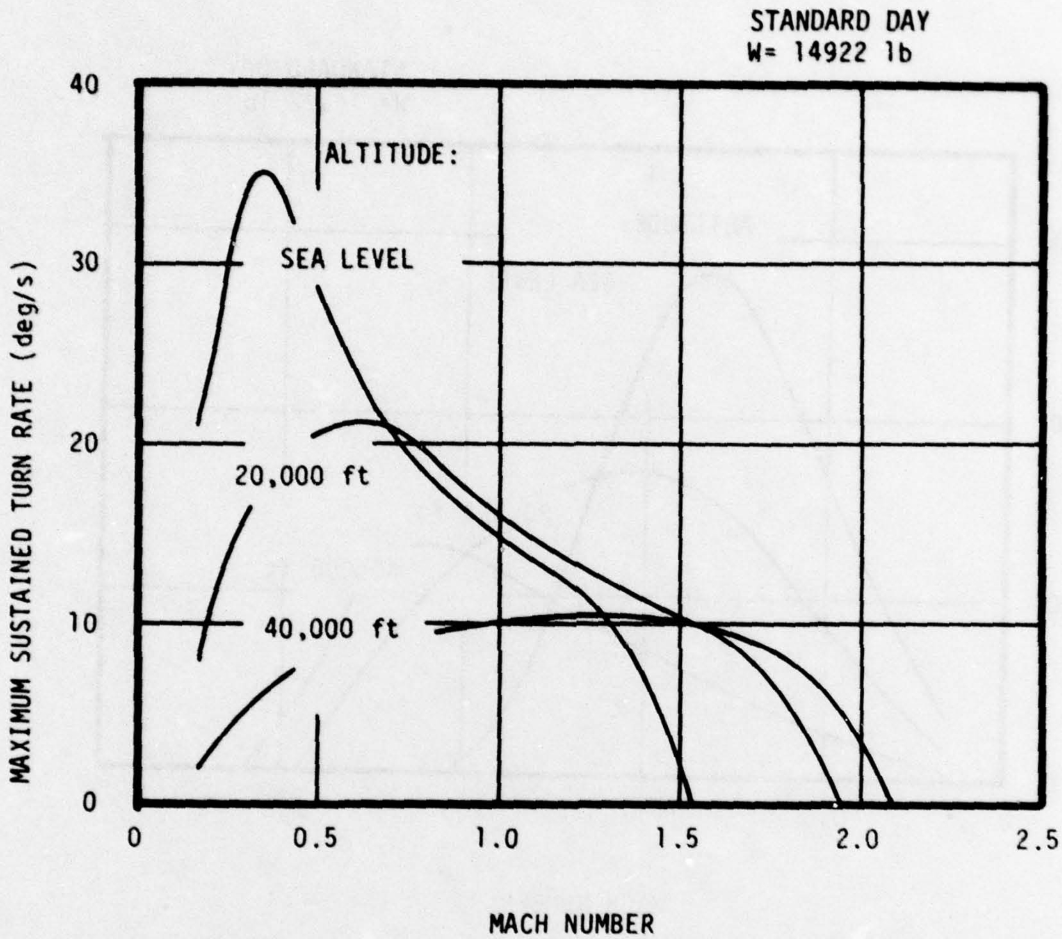

Figure 6 - Turning Performance

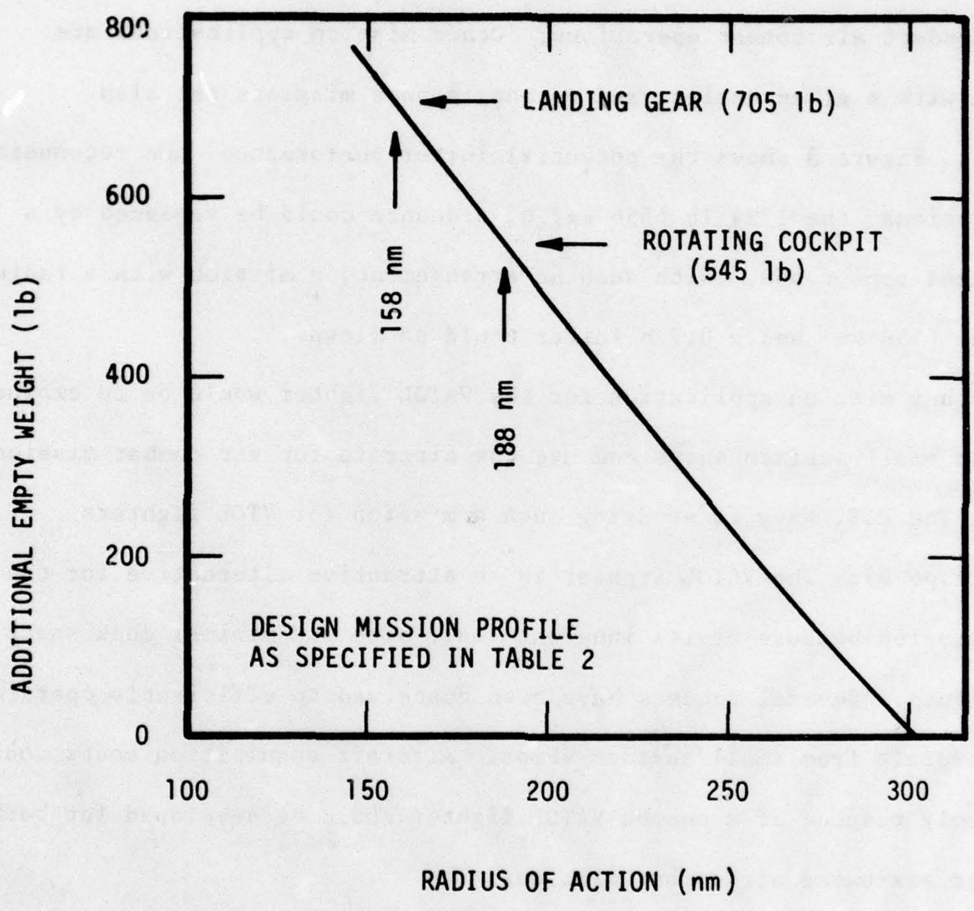

Figure 7 - Impact of Additional Aircraft Empty Weight

identical range-payload performance to the baseline (single engine VATOL fighter.

OTHER AIRCRAFT APPLICATIONS

The VATOL aircraft was designed to operate from protected land bases and to conduct air combat operations. Other mission applications are possible with a given design, and reconnaissance missions are also possible. Figure 3 shows the potential loiter performance. On reconnaissance missions, the 1224 lb (556 kg) of ordnance could be replaced by a specialized sensor pod. With such an arrangement, a mission with a radius of 300 nm (556 km) and a 0.7 h loiter could be flown.

Another mission application for the VATOL fighter would be to expand basing to small surface ships and use the aircraft for air combat missions at sea. The U.S. Navy is studying such a mission for VTOL fighters (called Type B). The VATOL fighter is an attractive alternative for the Type B mission because of its inherent small size and minimal deck space requirements. Several schemes have been conceived to efficiently operate VATOL aircraft from small surface ships. Aircraft acquisition costs could be markedly reduced if a common VATOL fighter could be developed for both land- and sea-based air combat missions.

CONCLUDING REMARKS

The VATOL fighter design presented represents a moderate risk approach to the design of a lightweight VTOL air combat aircraft. The combination of a single engine and the absence of conventional landing gear

results in an aircraft with the comparable performance of a conventional fighter aircraft. This VATOL concept, unlike all other VTOL concepts, results in a minimal increase in aircraft gross weight. Although costs were not determined in this study, the small size of the VATOL fighter indicates relatively low acquisition and life cycle costs compared to other VTOL fighter aircraft and is perhaps more comparable to conventional fighter aircraft. The VATOL fighter offers an attractive alternative to runway-dependent, conventional fighters in terms of aircraft size, complexity, and performance. Thus, further design and cost analyses are warranted.

REFERENCES

1. Martin, C.J., "An Assessment of the Technology and Potential for V/STOL in Europe," Office of Naval Research, ONR London Report R-3-78 (Jul 78).

2. Kuhn, R.E., "An Examination of the Factors Affecting the Thrust Requirements and the Hover and Short Takeoff Performance of Several Jet V/STOL Fighter Concepts," DTNSRDC/ASED-78/08 (May 1978).

3. Nicolai, L.M., "Fundamentals of Aircraft Design," University of Dayton, Dayton, Ohio (1975).

4. Green, W., "The Observer's Book of Aircraft," Frederick Warne & Co. Ltd, London, England (1978).

DTNSRDC ISSUES THREE TYPES OF REPORTS

1. DTNSRDC REPORTS, A FORMAL SERIES, CONTAIN INFORMATION OF PERMANENT TECHNICAL VALUE. THEY CARRY A CONSECUTIVE NUMERICAL IDENTIFICATION REGARDLESS OF THEIR CLASSIFICATION OR THE ORIGINATING DEPARTMENT.

2. DEPARTMENTAL REPORTS, A SEMIFORMAL SERIES, CONTAIN INFORMATION OF A PRELIMINARY, TEMPORARY, OR PROPRIETARY NATURE OR OF LIMITED INTEREST OR SIGNIFICANCE. THEY CARRY A DEPARTMENTAL ALPHANUMERICAL IDENTIFICATION.

3. TECHNICAL MEMORANDA, AN INFORMAL SERIES, CONTAIN TECHNICAL DOCUMENTATION OF LIMITED USE AND INTEREST. THEY ARE PRIMARILY WORKING PAPERS INTENDED FOR INTERNAL USE. THEY CARRY AN IDENTIFYING NUMBER WHICH INDICATES THEIR TYPE AND THE NUMERICAL CODE OF THE ORIGINATING DEPARTMENT. ANY DISTRIBUTION OUTSIDE DTNSRDC MUST BE APPROVED BY THE HEAD OF THE ORIGINATING DEPARTMENT ON A CASE-BY-CASE BASIS.